Technical Report Documentation Page

1. REPORT No.

2. GOVERNMENT ACCESSION No.

3. RECIPIENT'S CATALOG No.

4. TITLE AND SUBTITLE

Use of Surface Area Analysis in the Design of Bituminous Paving Mixtures

5. REPORT DATE

November 1949

6. PERFORMING ORGANIZATION

7. AUTHOR(S)

F.N. Hveem

8. PERFORMING ORGANIZATION REPORT No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

10. WORK UNIT No.

11. CONTRACT OR GRANT No.

13. TYPE OF REPORT & PERIOD COVERED

12. SPONSORING AGENCY NAME AND ADDRESS

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The design of a bituminous paving mixture generally involves the following steps:

1. A selection of the mineral aggregates which may be subject to choice on the part of the engineer or by necessity may be confined to certain materials.
2. There may often be a choice in the method of construction, whether by road mixing or by plant mixing.
3. The weight of vehicles and the volume of traffic to be carried must be known and evaluated.
4. An adequate foundation must be provided.
5. The designer may then combine the various sized fractions of the mineral aggregates and introduce a carefully proportioned and controlled quantity of asphalt to provide a paving mixture that will satisfy all of the essential requirements.

17. KEYWORDS

18. No. OF PAGES:

10

19. DRI WEBSITE LINK

http://www.dot.ca.gov/hq/research/researchreports/1930-1955/49-08.pdf

20. FILE NAME

49-08.pdf

This page was created to provide searchable keywords and abstract text for older scanned research reports.
November 2005, Division of Research and Innovation

4445
C.2

TRANSPORTATION MATERIALS
& RESEARCH LIBRARY

USE OF SURFACE AREA ANALYSIS IN THE DESIGN OF BITUMINOUS PAVING MIXTURES

F. N. Hveem

49-08

November 25, 1949

ClibPDF - www.fastio.com

4445
C. 1

LIBRARY COPY
Materials & Research Dept.

USE OF SURFACE AREA ANALYSIS IN THE DESIGN OF BITUMINOUS PAVING MIXTURES

F. N. Hveem*

The design of a bituminous paving mixture generally involves the following steps:

1. A selection of the mineral aggregates which may be subject to choice on the part of the engineer or by necessity may be confined to certain materials.

2. There may often be a choice in the method of construction, whether by road mixing or by plant mixing.

3. The weight of vehicles and the volume of traffic to be carried must be known and evaluated.

4. An adequate foundation must be provided.

5. The designer may then combine the various sized fractions of the mineral aggregates and introduce a carefully proportioned and controlled quantity of asphalt to provide a paving mixture that will satisfy all of the essential requirements.

It is recognized that the essential properties or characteristics of a good paving mixture include: a sufficient degree of workability, flexibility, durability, porosity or permeability, non-skid surface texture and finally, stability or ability to resist plastic deformation. A designing engineer must know where to look for characteristics or properties of the aggregate or the asphalt that will accomplish or influence these desirable

---

*Staff Materials & Research Engr., California Division of Highways

ClibPDF - www.fastio.com

characteristics. The relative importance of the several properties will vary depending upon the type of traffic and the climatic conditions under which the pavement must serve. Any intelligent design based upon engineering principles must be carried out to satisfy these ultimate ends.

It seems that in many cases certain single properties or identifying characteristics of pavements have come to be an end in themselves. This is most frequently true when considering voids or density. It is not uncommon to find that engineers proceed as though density of the mix is the sole criterion and having determined the void volume and filled the voids with asphalt, the "ultimate" has been accomplished.

It is desired to stress the viewpoint that such things as void volume, relative densities, surface area and similar items are only significant so far as they may indicate something of the essential properties enumerated above. Therefore, estimates of the void volume or calculations of surface area equivalents are simply short-cuts for reaching the best combination. Neither of these items are properly classed as "basic" or "fundamental" factors.

Taking up the important properties, a few comments on the factors that bear upon these items may be in order.

Workability - The term is meaningless except when considered in reference to some proposed construction procedure. Practically any combination of asphalt and aggregate can be handled and put in place with the proper equipment and under

ClibPDF - www.fastio.com

proper temperature conditions. Therefore, a conclusion as to whether a certain paving mixture is workable or not depends almost entirely upon the method of construction and prevailing temperatures.

Flexibility is also a relative matter. All pavements including Portland cement concrete are flexible to some degree and there is some variation in the degree of flexibility displayed by the several varieties of bituminous pavements. The question of how flexible a pavement should be depends primarily upon the degree of resilience in the foundation. With a very rigid and uncompressible base, the question of flexibility becomes rather unimportant. However, over many soils, flexibility can be very important and many stable pavements have failed over resilient foundations which were nevertheless capable of sustaining the load.

Durability of an asphalt pavement in the majority of cases depends primarily upon the ability of the asphalt to resist change.

The importance of permeability depends entirely upon circumstances. In many cases bituminous pavements that are permeable to the passage of water vapor will stand up longer than when tightly sealed if there is a plastic clay in the base material. On the other hand, dense, impermeable mixtures may have greater durability because the asphalt is protected from rapid oxidation.

ClibPDF - www.fastio.com

Finally, the degree of stability required depends upon the weight and number of vehicles to be carried; upon the speed of traffic; and very definitely upon the depth or thickness of the bituminous pavement layer. Thin bituminous wearing surfaces resting upon a solid foundation need not be highly stable in order to resist deformation under traffic.

No where in this foregoing discussion of the various properties and the variables involved has the question of voids or surface area appeared.

If any freshly prepared bituminous mixture is examined by eye or under a low powered microscope, it will be evident that the asphalt exists largely as a coating on the particles. The common terminology of practical asphalt men includes many references to the appearance of the mix and whether or not all particles are coated. In view of the fact that mixing really involves only a sort of wiping or spreading action, it is best regarded as a "painting" or coating process. It seems quite reasonable and more or less obvious that if the total amount of superficial surface on the particles can be measured or computed, this surface area should furnish an index to the amount of asphalt that would be required. It is also well-known that for a given weight of aggregate, the total surface area increases as the particles are reduced in size and if all particles are of the same shape, a calculated surface area equivalent could be quite accurate. However, particles of stone, sand and dust vary in shape and in surface texture;

ClibPDF - www.fastio.com

therefore, the calculated surface area is only an approximation that parallels the amount of surface contributed as the result of particle size. It is not feasible to calculate available surface due to pits and irregularities in the particles or the additional surface contributed by pores which are simply an extension of surface into the interior of the stone particles.

The "stability" or resistance of pure asphalt is not sufficient to withstand the stresses developed by pneumatic tired vehicles, therefore, it is necessary to depend upon the frictional resistance developed by stone particles in contact. This means that the asphalt content must be restricted to a volume less than the total void volume, but experience has shown that there is no fixed relationship between the volume of voids and the volume of asphalt when all types of aggregates and asphalts are considered. Therefore, the voids method of design can be utilized with confidence only for a certain type of grading which produces rather dense mixtures. In such cases, the optimum amount of asphalt is only slightly below the total void volume. A large percentage of the asphalt pavements that have been constructed in the last fifty years have been "designed" from "experience" which means that the choice of gradation and type of asphalt have been narrowly limited and many practicable possibilities have been completely overlooked or discounted for this reason.

ClibPDF - www.fastio.com

On the other hand, if we proceed on the premise that the amount of asphalt corresponds to the amount required to coat all of the aggregate surfaces, we have only to decide upon the appropriate thickness of film and to measure or estimate the available surface to be coated. Analysis of many examples of satisfactory and unsatisfactory mixtures brought forth evidence that for satisfactory results the average film thickness (which the late Mr. A. R. Ebberts designated as the bitumen index) must vary inversely with the amount of surface. In other words, the finer the particles and the correspondingly greater available surface, the smaller must be the bitumen index or film thickness equivalent. It is furthermore evident that the harder grades of paving asphalt do not perform satisfactorily when the film thickness is reduced too far, but the same limitations apply in lesser degree to the more liquid grades. Therefore, we have limitations imposed by the nature of the asphalt to the effect that when mixtures contain a great deal of fines and consequently a high surface area, a point is ultimately reached where the use of hard asphalt becomes impracticable and undesirable. At the other extreme, with very coarse open graded mixtures low viscosity road oils and liquid asphalts cannot be maintained in the heavy films that are appropriate for such coarse aggregate gradations representing low surface areas.

ClibPDF - www.fastio.com

The most rapid and widely applicable method of estimating the amount of asphalt that is appropriate for a given combination is by means of the Centrifuge Kerosene Equivalent determination, which is a rapid method for evaluating the total available surface of the particles including particle roughness and porosity. While developed for California conditions and materials, this method should be applicable to any bituminous binder and requires only minor adjustments to allow for the consistency of the particular bituminous material. A copy of a paper describing the application of the Centrifuge Kerosene Equivalent Method is attached. The total time required is about fifteen minutes. The sole purpose of the C.K.E. determination is to arrive at a close approximation of the maximum amount of asphalt which can be tolerated without producing instability. The upper limit to the amount of asphalt used depends upon only two considerations; the question of stability and the need to maintain a non-skid road surface. All other considerations are benefitted by increasing the amount of asphalt. Therefore, if we ascertain the maximum amount which can be used without adversely affecting the stability, we have then arrived at the best compromise for all factors involved.

ClibPDF - www.fastio.com

The foregoing discussion is intended to imply that it is possible to decide upon the most appropriate quantity of asphalt by means of estimating the surface area of the particles and knowing the film thickness that is appropriate for the particular surface and the type of asphalt. It does not guarantee that the resulting mixture will be highly stable as the stability or ability to resist plastic deformation depends primarily upon sliding resistance between the particles and secondarily on the cohesive forces or tensile strength developed by the films of asphalt. The only satisfactory means for evaluating the stability is by means of some testing device which measures the internal friction as it may be modified by the lubricating effect of the asphalt. For a more precise evaluation, it is necessary that the tensile strength or cohesive value also be determined by test. In the process of measuring stability in the Laboratory, the differences in the nature of these two properties must be recognized as results can be misleading when a test procedure tends to emphasize one property in comparison to the other.

Tests such as the Stabilometer may tend to underrate plastic mixtures having high surface areas and a comparatively high percentage of low penetration asphalt.

Other test methods such as the various forms of load penetration test and unconfined compression methods tend to overemphasize the cohesive forces and invariably indicate as optimum an amount of asphalt higher than that which will give the best performance under traffic.

ClibPDF - www.fastio.com

To summarize the viewpoint of the writer, the surface area method is a very useful tool and through its use it is possible to closely estimate the amount of asphalt that will give optimum results. The procedure is applicable to all types of mixtures ranging from very dense combinations with fine aggregates to very coarse gradations and may be adjusted to accommodate all grades of asphalt.

By the use of the C.K.E. method, the surface capacity may be rapidly determined with allowance for particle characteristics as well as gradation. The method has been used for over seven years with consistent success.

ClibPDF - www.fastio.com